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NATURE STUDY

ITS PSYCHOLOGY METHOD AND MATTER

By S. SILCOX, *B. A., B. Paed.*

For the Degree of Doctor of Pedagogy.

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EXAMINERS' CERTIFICATE

To The Registrar of the University of Toronto:

We beg to report that the thesis of Mr. S. Silcox and his very creditable discussion of the questions set in Philosophy and Ethics, and in the Science and Art of Education, qualify him for the Degree of Doctor of Pedagogy, with second class honors.

John Watson.
J. A. McLellan.

The Psychology of Nature Study.

"Mind grows only in so far as it finds expression for itself."—HINSDALE.

"Education is a process of remaking experience, giving it a more socialized value, through the medium of individual efficiency"—McLELLAN.

The process of remaking experience is inseparably united with expression. This process is from the vague to the definite, from real to ideal. This latter expression is apt to be misinterpreted unless restated in other words. We mean by it here that education is a process by which the individual becomes more and more independent of material things as a stimulus to thought and in expressing thought. Thought and expression cannot be divorced. The power of expression, though conditioned by thought, is yet the means by which thought is made definite, and is thus communicated to others.

The growth of mind is a process of analysis followed by synthesis. A child should not be allowed to analyze anything without following up that mental process by an act of synthesis, *i. e.*, expression. The expression is the visible sign by which we can value the thought, and it determines the nature and the extent of analysis of the material of study.

This correlation of analysis and synthesis is so fundamentally important that the psychology of any subject is necessarily dependent upon it. A basket may be analyzed and if so, one should be made like it. When natural objects are analyzed, often the only possible synthesis is a drawing of the object, but this form of expression is possible to any great extent, only after eight years of age. To determine the extent of the analysis which may be made at any age, we have only to determine the power of expression possible at that age. A child is quite able to analyze, that is, to tear to pieces, mechanically, a delicate flower, but if he is unable to represent this analysis, either by a drawing, by a model, or by words, the analysis is a waste of time; nay, worse, it gives the destructive bent of the mind an impetus, which, unbalanced as it is by constructive ability, can lead only to mental dissipation.

No one would think of asking a child of seven years of age to model the parts of a flower nor all the sinuosities of a leaf margin, the indentations of bark, nor the structure of a cell. Yet we often find teachers endeavoring to teach very young children all these details of form and structure. They are forcing their pupils to analyze without possessing the power to synthesize and will fail in securing proper development.

An example from the teaching of number in arithmetic will make clear the necessity of both processes. Suppose a teacher is teaching the number seven. She has taught six, and now hands each pupil seven sticks with instructions to take a stick six times in the right hand and a stick one time in the left hand. Would any teacher think of stopping there? I think not. She will require that

the sticks be put together again and the whole process described. A similar analysis and synthesis is necessary in all mental activity, but we must acknowledge that in too many cases we have neglected one-half of the operation.

And herein is the value of language. The teacher can never be sure that the pupil performs the synthesis unless he is able to express himself in fairly exact language. At best, modelling, drawing, diagrams are limited, if not by executive ability, then by stress of time and lack of equipment and space. Consequently each step in analysis must be associated with descriptive terms of some kind, technical or colloquial. If the pupil cannot make such a verbal synthesis, the analysis is premature. On the other hand, the verbal synthesis may be tested by demanding that it be put into the more concrete form of the drawing or model.

The Modes of Expression.

Thought finds expression in the following ways:

(1) Gesture (including facial expression).
(2) Modelling.
(3) Drawing (including form, color or shade, and proportion).
(4) Diagrams (in which details are omitted).
(5) Language (oral or written).
(6) Singing, the social mode of expression.
(7) Calisthenics, also social in nature.

While it is true that all modes of expression have a social as well as an individual side, singing and calisthenics are pre-eminently social, while the others are pre-eminently individual; that is, the first five are the expression of individual activity, while the last two are the expression of the social instinct.

Gesture may be made a means of communicating thought, but it is usually an accompaniment of oral speech. Facial expression and bodily movement are the signs of emotion, *i. e.*, the personal element, while the language used represents the universal element of knowledge. So long as these two elements enter into thought, we shall have gesture and speech together.

Gesture is perfect in the young and becomes less prominent as development proceeds from real to ideal, because knowledge becomes more universal. At least the individual recognizes the universal element more, whereas, at first he recognizes only the personal element. The mechanical grind of learning by rote will soon eliminate the personal element and will give rise to that vacant stare and listless manner of the unfortunate spoon-fed pupil, who is taught not to think, who takes no interest in the work of the class-room. Compare the vivacity of that boy over a game of marbles with his listlessness in the schoolroom and then think what the result in after life will be, when the fluctuations of the stock market are more interesting than the beauty of nature and of art.

Modelling.

Before a child learns to describe form and proportion, he can represent these in models. There are all grades of representative ability in this, from the model in crude clay to that of an intricate and complex machine. There is

no stage of existence in which it is not an essential mode of expression, notwithstanding the fact that many educated (?) men can scarcely "whittle" with a jack-knife. The perfection of the model depends upon the power of analysis, accompanied by the power of synthesis. To become efficient in modelling one must analyze the object. To become an efficient analyzer one must model, must he not? It is in the attempt to model an object that one learns wherein his analysis was defective, just as in the higher stage, defective expression in speech discovers defective analysis of thought. During the presentative stage, the child cannot discover his faults of analysis by any more ideal mode of expression than modelling. The teacher may point out defects of analysis but this is not cultivating the child's self-actvity.

Drawing.

Drawing is a more ideal form of expression than modelling. The representation is limited to two dimensions in space (surface), though the third dimension is represented by an illusion of perception. At first, however, the child's drawings are somewhat diagrammatic in appearance, though by no means so in reality. Instead of eliminating details as is done in a diagram, every detail is represented, even though it be not apparent from the point of view. The drawing is too real at first. The child must learn to leave something to the idealizing power of mind. The point we wish to emphasize, however, is that drawing is a mode of expression of thought, and should not be divorced there-from as it too often is. Also, every child in its life passes through a stage when drawing is the predominant means of thought expression. It may be possible for a few to miss this stage and still acquire the right mental development, but for the great majority, the commonplace men and women, it is essential that this mode of expression receive attention at the proper time. This time will probably come between the years of eight and twelve, during which time the motor centres of the brain are developed. If not developed at this age, there must be serious deficiency in mental equipment.

Probably the most common mistake in connection with drawing and the use of pictures in general in school, is the neglect to interpret illustrations. Just as in studying Latin, it is essential to translate from Latin to English and from English to Latin, so in making use of illustrations we must illustrate our thoughts in drawing, and also interpret the thoughts of others as expressed in their drawings. By such a process we make the transition from this stage of expression to the higher stage of oral or written expression. This transition is quite as important in its time and place as is the transition from modelling to drawing.

Diagrams.

Here, again, is an important mode of expression which has been entirely overlooked. Probably the majority of educationists would consider it a convenience rather than a necessity. Yet, in the world of science, at least, it is more important than drawing. It is scarcely possible to make a drawing that would have any scientific value. At any rate, it is of far less value than a good diagram, which expresses a general principle. The diagram is the concrete way of expressing a principle and is the logical method of introducing it, just as we begin to

arouse mental activity by the use of objects. And here again the child can discover its faults of analysis by making a diagram to represent the generalizatiion.

A good example of the use of a diagram is seen in representing the inflorescence of plants. No two modes of flowering are exactly alike, yet, neglecting all other differences, we find that they agree in the order of unfolding either from the centre outwards or from the outside to the centre. A diagram may be readily constructed to show this one agreement. The agreement can be shown most clearly by making drawings of the flowering of different plants and then comparing these drawings. Thus the diagram is seen to be a more ideal representation than the drawing and is the necessary transition to the still more ideal method of representation by pure symbols, which, as yet, are too ideal for the child to make extensive independent use of, as he may later. The greater concreteness of the diagram makes it possible for the child, at this period, to discover his own errors of analysis by comparing the diagram with the drawings from which it was constructed.

Language.

We are accustomed to think of oral and written language as the distinctive acquirement which distinguishes man from the beast. But, except gesture, all the other modes of expression are equally distinctive of man. There is no doubt that animals possess a rudimentary gesture language, and also a language of touch, of smell and sound, but these are not ideal modes of expression, and no attempts are made by animals to represent their ideas by means of any kind of symbolic language.

No more ideal method of communicating thought indirectly can be conceived of. Some claim, however, to communicate thought directly, but when analyzed, all so-called thought-transference resolves itself into a more concrete mode of expression than the use of symbols. Mind readers usually have an extreme susceptibility to pressure, to gesture, or to sounds, which are inarticulate to the ordinary ear.

Ideal language is more than the association of a particular sound with a presented object or action. It expresses the mental relationship which results from presentations, stimulating the mind, and as such is purely ideal. It can scarcely be said that the sign bears any resemblance to the relationship which it expresses. It might have been something else, though, doubtless, each symbol has been evolved in an orderly and scientfic manner. This evolution is still going on and in time we shall possess a still more ideal mode of expression. Indeed we have it now in shorthand, which will become, eventually, the written speech of educated people.

Singing and Calisthenics.

It has always been recognized that music has a powerful influence over the individual emotions and character. But we usually lose sight of the fact that the rhythmical nature of singing and calisthenics is the bond which unites individuals in these activities. They are peculiarly social activities; in modern times, usually

associated with poetry. Hence the importance of including these activities in educational life, especially in the lower years, which, according to the culture-epoch theory, corespond more nearly to the tribal period of the race. The Kindergarten is the only period in school life in which singing, accompanied by rhythmical motion, forms an integral part of the school exercises, but this should extend far beyond the Kindergarten age. If singing has been found so beneficial in religious exercises, surely it has a beneficial effect in educating the moral sense.

Stages of Mental Development.

Nature Study must conform to these general principles, which underlie the relation between thought and expression, but like other subjects must be adapted to the stage of mental development of the students. There are three well recognized stages in mental development, which corespond to three well marked stages of physical growth. Close observation and study of children have shown that the period of childhood up to eight years of age is one of rapid growth, both of mind and body. It is a period of great susceptibility to impressions but with slight power of retention. It is, therefore, essentially an impressionist period.

From eight to twelve years of age, there is little growth but there is great development, nevertheless, in at least the lower mental activities. Health is good, muscles firm, the brain retentive. With, perhaps, diminished impressibility, there is increased power of retention, which is very characteristic of the period. It may be called the retentive or representative or more simply the secondary stage. After twelve years of age, growth becomes rapid again, and in a year or two sexual development becomes marked. This characterizes the period as one of relationship. Relations of ideas develop; relations of self to society; of man to God. It is the stage of thinking.

We shall use the terms primary, secondary, and tertiary, to indicate these three stages instead of the more technical terms, which may arouse preconceived notions.

We have to consider in each stage: (I.) how ideas are aroused; (II.) the nature of the ideas aroused: (III.) the mode of expressing the idea; (IV.) the subjects of study best adapted to the stage.

The Primary Stage.

In all stages mental development must be associated with the constructive activity of the child, hence, the ideas aroused and the mode of expression are indissolubly combined except for purposes of analytic discussion. In the primary stage, ideas should be aroused by *direct* stimulation of the senses. The child should see, handle, taste the object and operate upon it in some way to adapt it to his ideal end. In thus operating upon objects under the direction of his teacher, he comes to recognize them, first as wholes, then as integrated parts, and associates with them the symbols by which society knows them. This recognition and association involves the higher mental activities, implicitly but not explicitly, and thus lays a foundation for the discovery of more ideal relationships in the higher stages.

This brings us to a consideration of the ideas aroused. Expressed in technical terms they are sensations and perceptions, but they are far from definite. While each sensation is sufficiently clear to convey knowledge, it is not such knowledge as the child will gain from later sensations. Memory is present in the act of perception, but it is limited to the association between the former experience and the experience which recalls it. The child cannot continue a train of associations beyond very simple associations by contiguity, though I knew a child two years of age who carried out this train, beginning from a copper which was in her hand: "copper—daddy—bank—nanny," meaning that her father was in a bank where there were lots of coppers, which could be be used in buying bananas. Probably any image which arises in the child's mind at this age is believed by the child to be aroused by an object or, at least, the child is incapable of distinguishing those images which have been aroused by actual stimulation of the nerve endings and those which are the product of the imagination. Instead, therefore, of saying that a child of this age is imaginative, we contend that he does not as yet know the distinction between real and ideal.

Expression in this stage is most effectually and definitely made by gesture and by modelling; drawing and oral description being comparatively undeveloped modes of expression, so much so, that they cannot be sufficiently accurate and perfect modes of expression, to enable the child to make a synthesis in anyway appropriate to the analysis which he makes. Wherever detailed expression is desired, resort must be made to modelling.

It is a question whether the higher modes of expression will be adequate, if this mode is omitted. I think they will not. As society becomes more complex, there is less and less incidental expression by modelling at the age when expression of this nature is essential; hence the greater need of providing for it in connection with the regular school work. Fortunately the play instinct, if unhampered, will not let this mode of expression completely die out.

The modelling in this primary stage will be the simpler process, in which the material remains unchanged, except in form, size and shape. Neither mind nor body has as yet been sufficiently differentiated to secure precise movements such as are required where material has to be changed in structure, in order to adapt it to particular use, e. g. carpentry.

The subjects of study best adapted for this stage, are therefore, those subjects which call for expression by gesture and modelling and which do not demand the exercise of memory, imagination, and the powers of thought, except incidentally. The child should study objects which are associated with his daily life and which he can observe in their natural relations. These objects should be comprehensive in structure, not particular. They should appeal to the child's love of activity, and of the novel in its relation to the familiar. This limits the child's study to his immediate environment, and to things which appeal directly to his senses. Evidently the phenomena and the things of nature should be the basis of the child's mental development in this period. In connection with these he may measure and learn the rudiments of arithmetic and also begin the recognition of the symbols which stand for these things and thus learn to read. So exact and ideal a form of expression as writing should occupy a very unimportant place

while drawing and oral expression should be gradually developed, as precision of constructive activity makes these possible.

The Secondary Stage.

The secondary stage is one of great activity and the physiological condition makes possible greater precision of movement. There should accordingly be a better adaptation of means to end in his reaction upon his material environment, which he will now *begin* to view in its relation to social life. Direct stimulation of the senses must continue as before but indirect stimulation should gradually become more important. Objects need not be actually present but may be represented by pictures, diagrams, etc., assisted, of course, by oral description, which, however, is still subsidiary. The nature of more remote things is conceived through his increased power of idealization. Hence interest widens beyond the immediate present, which is actual, and enters the domain of imaginative activity.

Ideas in this stage become more definite. Vague wholes, by the process of analysis, are more clearly comprehended. Sensations and perceptions revive images of objects not present, and images are constructed of experiences which have not yet had existence in fact but which *may* be realized. There is, therefore, a great advance in ideal development, and at the same time there is a differentiation of what has been realized from that which still remains ideal or merely imaged.

The mode of expression will now be by reconstruction of material in the model in wood or in metal and by drawing; these two processes being complementary. A model is made from a drawing and the object studied is represented for future use and reference by a drawing. While in the preceding stage, material was studied as it affected the senses directly, it is now studied in its relation to man; in its use as a factor in socializing the race; for all this adaptation of material to use has been the expression of higher social ideals.

The aim of drawing should not be to secure perfection of form so much as to secure free expression of thought. The perfect form will eventually follow, if the thought of the perfect form is there. Then by interpreting the drawing either in the concrete material, e. g. wood, or by a verbal description, both thought and expression are made more definite.

The secret of correct drawing and exact making is comparison. The teacher will insist on the comparison of (I.) parts of an object with the whole; (II.) parts with each other; (III.) wholes with each other. All such comparison and adaptation is a process of abstraction, so that the pupil is being prepared for a higher stage of mental development.

The subjects of study for this stage are, therefore, those which involve the study of material and the processes by which this material has been made to serve social progress. But as mental development has not yet reached the stage of discovering laws and underlying principles, the study must be limited largely to gaining information about these materials, and repeating *in a limited way*, some of the typical processes which have influenced social progress. The teacher will now find memory and imagination active and need not depend upon actual presentation of material, but may extend the field of operations by the use of pictures, etc.

The study of nature is evidently all important here It supplies all the materials, which, by adaptation to human needs, have been the basis of progress. In connection with these materials, geography becomes an important study. Arithmetic must be studied in relation to adaptation of materials to suit man's increasing needs. Present complex society can be understood only by the study of former simpler modes of living-history. Imaginative literature finds a responsive chord in the child's mental state. The foundations of the sciences should be laid in this period by making the child acquainted through his own activities with the fundamental facts.

The Tertiary Stage.

In the third stage, the child should become more independent of objects and their representations and more proficient in the use of symbolic modes of expresion. If the education up to the age of twelve or thirteen years of age has provided the pupil with a good stock of fundamental facts, learned by his own sense activity, and in connection with his constructive activity, he will be in a position to use language extensively and to learn new facts through the medium of language. Then he should be occupied chiefly in discovering relations between facts rather than facts themselves; at least his motive in discovering facts is now for the sake of their relations. Reason becomes the arbiter of what is and what is not. All experiences must be subject to rigid examination in order to discover the *true* relations. Instead of comparing objects and their features, which is of course, a relating, ideal process he must now compare ideas, a still higher relating and more ideal mental process. He must classify, judge, and reason.

The most important feature of this period, the age of puberty, is the development of the idea of social relationship. The child becomes conscious of self, as a unit in a larger whole, just as he formerly became conscious of himself as an individual, distinct from the whole. He also becomes conscious of the distinction of sex and interest in the opposite sex occupies a large part of the mental field.

The ideas aroused are more abstract than in any preceding stage. Their content is more ideal, less limited by time and space conditions. The relations of cause and effect become predominant. Hitherto this relation has been apt to be determined by *post hoc ergo propter hoc*, but now such relations are seen to be unimportant. He discovers the essential conditions of phenomena by a process of abstraction and diagnosis by exclusion. Why becomes the all important question, as how, what, and where have been important heretofore. The search for the underlying principles of things has now *begun*.

The mode of expression must accordingly be more ideal than formerly and that is by the use of arbitrary symbols, oral or written. Spoken and written language should now become the thought medium in the final count. It is, in fact, impossible to express the higher ideal relations of the higher mental state by those modes which are sufficient in the lower. An ideal relation may be *exemplified* by a model, drawing, or diagram, but cannot be *fully expressed* so. As language is developed there will be less and less need of drawing and modelling, though for purposes of communication it may be necessary to convert the symbolic expression into picture language, or the language of the model, in order to adapt it

to the mind which is to be acted upon by it. Hence the necessity of having learned those modes of expression at the proper time, inasmuch as the majority of minds respond, adequately, only to the lower modes of expression. Our constant aim as educationists should be to make our pupils independent of these lower modes, not by ignoring them entirely as we have been doing, but by arousing and developing them at the proper time.

The subjects of study for this stage, therefore, will be those which emphasize the social side of life, and which demand the exercise of the thought powers. The constructive activities should be exercised throughout as the basis of "remaking experience." Subjects which require classification are essential, such as botany, geography, zoology, grammar. The deductive sciences, arithmetic and grammar, will cultivate judgment and reason; history, properly taught, will also exercise the reasoning. Any series of related facts will furnish material for the thought powers; hence, any of the above subjects will cultivate thought. The attempt to explain the various phenomena of nature will bring into operation all the thought-powers, hence, elementary science should be a subject of study in this stage.

The Subjects of Study.

If we now make a list of the subjects of public school study and place opposite each study the mode or modes of expression usually associated therewith in the class-room, we shall be able to see more clearly the relative value of each subject in the three stages of education up to the age of sixteen.

Subjects of Study	Mode of Expression
Arithmetic	Diagrams and Speech
Grammar	"
Literature	Speech
History	Speech
Geography	All the modes
Physiology	"
Nature Study	"

Though history and literature are usually associated with speech only, it is quite easy to cultivate all the modes in these subjects.

The remaining subjects, usually placed on a curriculum as subjects of study, are not properly speaking subjects of study for public school pupils at all. There is a scientific study of these modes of expression as they are related to the regular branches of study, but such a study is not suitable for public school pupils. These so-called subjects of study, reading, writing, drawing, and composition, are simply modes of expression for thought. Having failed to recognize the absolute necessity of making use of these modes of expression, except reading and writing, we have thought it necessary to give them a distinct place in the school curriculum as subjects of study. By this act of placing them on the curriculum so, the evil has been intensified, and we are compelled to witness meaningless exercises in combining sentences, filling blank spaces, correcting false syntax, changing the forms of sentences, the conjugation of the verb, under the name of composition. The composition has been accomplished already in

such exercises. We are simply asking our pupils to shift counters on the surface of their paper. It is just as mechanical as making pothooks, right and left curves, straight lines, etc.

In addition to these subjects there are also manual training, domestic science, music and calisthenics, and commercial transactions. There is no reason why the elementary operations in connection with commerce should not be taught as a part of arithmetic, and take the place of purely abstract problems which so often find a place there. The change would be beneficial in all respects. Music and calisthenics have been sufficiently discussed. They are not subjects of study but social activities. Manual training and domestic science should not be considered as independent subjects of study any more than composition, reading, and drawing. In one sense they are modes of expression, but in reality are the underlying activities of all education. Under these headings are arranged a series of activities typical of the development of the race, and as the race, in this reaction upon materials from which food, clothing and shelter have been obtained, has learned to adjust environment to its needs; so must the child react in a more ideal way upon material, to learn how to adjust environment to its needs. The *processes* by which the race has developed must be repeated by the individual.

Geography is advanced nature study and physiology a branch of it. Practically, therefore, nature study is the one subject which demands all the modes of expression and is therefore adapted to each stage of education. Yet this is the subject which we have omitted from our curriculum, putting in its stead as independent subjects the very modes of expression which must of necessity be cultivated if the subject be properly taught. This is worse than asking a child to learn a foreign tongue to the neglect of his vernacular. We ask our pupils to pass by the wonders of creation at their very door and learn about "African lions, Roman emperors, mountains in the moon, and angels in heaven." What the Port Royalists did for the child in emphasizing the importance of the vernacular, the advocates of nature study are doing for the child of today. We discuss learnedly a Greek ode but fail to discern the great epic of creation writ large on every leaf, and twig, on field and wood, in sky and plain.

Once properly correlated with the other subjects of our school curriculum, the proper study of nature will revolutionize reading, drawing, and composition, if not writing and other school subjects. History is but the orderly account of Nature's masterpiece in his social relations, and literature is the product of a complex organization, which has its counterpart in the lowest organism. No other study is so comprehensive as nature and none is so accessible. It requires neither building, books, nor equipment, except such as nature has provided for us.

> "*Music in trees, books in the running brooks,*
> *Sermons in stones, and good in everything.*"

Nature has been and still is the immediate environment of the majority of the human race, and the senses have been adapted to detect its variations just so far and as long as necessary. The sense of smell has ceased to be an educative sense and taste has been reduced to a position of unimportance but all the other senses are still of vital importance.

In the evolution of the race natural objects were first of interest — utilitarian interest, and I think we are safe in saying that all interest is *based* on the

use of things. In time the savage learned to modify his natural environment. Instead of accepting the shade of the natural tree, he lopped off branches and enclosed himself in an artificial lodge. Thus began the art of architecture, the lowest mode of thought expression (modelling.) But the copy from which he modelled was an ideal one. The natural object—tree, cave or bank—suggested to his potential mind a more perfect structure. This ideal structure was eventually realized in the wigwam, tepee or artificial cave. These, in turn, suggested more perfect structures, and as these were realized there were development and progress. Those races which have not had ideals, or which have not progressively realized them, have ceased to progress. Why should the child pass through a similar process? What is to be gained by placing before the child the natural object, which is irregular and comprehensive, rather than the regular and particular manufactured form, e. g., sphere, cube, cylinder? Why should the child repeat the experience of the race? There are two reasons. (1) If the child proceeds from the irregular to the regular, he must put in to the process a personal element, an individual factor, and there will be progress. (2) As a result the child will be encouraged, since he has produced something "all his own"—something which, to him at least, is an improvement on the natural object, inasmuch as it has the element of individuality about it, which the original has not.

If the opposite course be pursued, and the child be given a perfect cube to examine, he cannot imagine a more perfect form, hence his individuality is not exercised to any extent. If he attempts to make a model of it, he cannot possibly make as perfect a form and will be discouraged. The study of the perfect geometric solids in the Kindergarten is plainly not in accord with sound educational principles. However, the nature study in the Kindergarten probably counteracts the evil.

The first argument, then, for nature study is that it furnishes suggestive and varied forms, in observing which the imagination is exercised and developed, and in modelling which, or the more readily suggested ideal forms, the child makes mental progress. This progress in turn makes the observing powers more acute and hungry for material to act upon. Dr. G. Stanley Hall, at the N. E. A., in July, 1901, said: "Less time should be devoted to arithmetic and reading before eight years of age, and more to nature study." If nature study is taught in the lower forms there will be no loss of time on account of it in the higher forms. We do not propose to lessen the training in literature, mathematics, etc., but to supplement it. The basis of composition, literature, geography, drawing, and reading, is the study of nature. The addition of this subject of study to the curriculum will not really increase the work, but will secure better results in the above subjects than was formerly secured without it, and with the expenditure of less energy.

In the secondary stage of education, nature study has a claim to our attention based on sound psychological principles. Drawing should be based on natural forms. Trees, flowers, and animals should be the concrete material for the first two or three years of instruction in drawing. Form, color, and proportion are all there in far more interesting combination than can possibly be made in the most expensive set of models obtainable. The mental activity required in selecting and relating the material at hand is the best possible kind of training.

As previously pointed out, the use of diagrams is made clear from the study of natural objects. The construction of diagrams is the first step in classification. We select one peculiarity which we find common to several objects. We express this in a diagram. We then use this as the type to which we find other objects conform, and conclude that all these belong to the same class.

Having laid a firm foundation through the use of objects, drawings, and diagrams, we shall have prepared our pupils for the highest stage of mental development — the study of relations, which, in itself, is purely ideal, for relationship exists only in the mind. Education may now depend principally on the use of mere symbols. The dominant mode of expression should be by symbols arranged systematically in what is known as written composition. What has nature study to furnish here? Simply the subjects for composition. Half the field of composition, i. e., narrative and descriptive, is bound up in nature. It forms the setting of more than half the literature for all time. What makes the charm of Parkman's history? It is the description of natural scenery and spirited narrative of the contest of man with man, and man with nature. There is, therefore, no stage of education in which nature study is not an important subject of study. It is all important in the first stage; equally important as any other in the second, and scarcely subsidiary in the third stage.

Of course, there can never be a divorce of any one stage of education from the others. In the first stage relations will be noted, and symbols used, and in the third stage, objects, drawings, and diagrams must always be in evidence. But each stage has its predominant mental activity, means of instruction, and mode of expression, to which the others are merely complementary.

What Human Needs are Satisfied by the Study of Nature?

1. INHERITED TENDENCIES AND INSTINCTS

Primeval man was entirely dependent upon nature, and we are still dependent, though often indirectly. Hence we need to study nature to understand her laws and thus preserve our lives.

Since the life of the individual is a repetition in miniature of the life of the race, it is desirable that, in each stage, the environment should be an *ideal* copy of that in which the race has made the most progress. Up till ten or twelve years of age, the child's sympathies are with animate and inanimate nature, and he should come in close touch with these. At the age of puberty interest in self and in the opposite sex occupies the mental field, and an ideal social environment should be created for his proper development.

Certain instincts of man are essential for the continued existence of the race. If these are not nourished at the proper time in a suitable environment, they perish. *A suitable environment is one that is similar to that in which the instinct was first developed. To improve the instinct the environment must become more ideal.*

A squirrel in captivity, on a hard floor, will attempt to bury a nut, it will scratch at the floor and leave the nut exposed. Under such conditions the impulse to bury nuts soon dies *and cannot thereafter be aroused*. So it is in the child. "In all pedagogy, the great thing is to strike the iron while hot, and to seize the wave of the pupil's interest in each successive subject before its ebb has come, so that knowledge may be got and habit of skill acquired — a headway of interest, in short, secured, on which afterwards the individual may float. There is a happy moment for fixing skill in drawing, for making boys collectors in natural history, and presently dissectors and botanists, then for initiating them into the harmonies of mechanics and the wonders of physical and chemical law." —JAMES.

Suppose the instinct were the fishing instinct, could it be aroused and developed in the vitiated atmosphere of a school room, conning over a description of some fishing expedition of past ages? No, of course not. At the age when this instinct stirs the blood, the boy must bend a pin, attach it to a cotton string, and with worm well set and properly mounted, go forth and sit in the glorious spring sunshine on a dry bank, at the base of a foaming rapid, beside some semi-transparent stream, and *feel* the exultant tug, experience the delight of hauling out the finny dweller of the stream, count up his store and even enjoy the weary homeward trudge, happy in his knowledge of something accomplished.

Why does the balmy spring air seem to invite me to far away streams and sunny banks, to the sugar woods, the camp, and the swing-pole? Because the

instinct was implanted by actual experience in nature's own environment, at the age when these desires first stirred the blood.

Inherited tendencies demand that we should come near to nature's heart in our childhood if we are not to lose entirely, in a generation or two, the God-given love of freedom in God's free air and sunshine.

We are "heirs of all the ages," but, as a race, are in danger of losing our heritage, the result of centuries of honest toil. Reaction upon environment to adapt it to human needs has become, to a certain extent, instinctive. Unless the children are made to repeat the *ideal constructive acts* before the age of fourteen the constructive powers will weaken and in a few generations die out.

2. ACTIVITY OF THE SENSES, AND MUSCLES.

In their normal healthy state, the senses and muscles desire activity in response to stimulations, and the pleasurable experience of such activity is the basis of the child's interest in the world about him. This interest is especially intense for moving things or for changing things. The former includes animal life and physical force; the latter, growing things, plants and animals, and material things, acted on by some force, physical or chemical, which produces change in shape, volume, appearance, hardness, or some other property. These form the basis of the sciences—zoology, botany, physics, and chemistry. The age during which the activity of these senses is most pleasurable and profitable in forming clear perceptions and in rousing mental activity, is from the age of three to the age of fourteen years, the end of public school life. If they are not exercised during that period, you will find what is too often found in our public school graduates, a lack of interest in things of sense or a want of confidence in the efficiency of the sense organs; or among teachers, a lack of the sense of the importance of cultivating the senses. The latter is painfully evident, but is the natural result of the public school training. Of course, training the senses is not an end in itself, but a means to a higher social life.

3. THE DISCOVERY OF RELATIONS.

In the third stage of education, the particular benefit of nature study is in furnishing material for the relating activity of mind. This activity is as normal and as pleasurable as the activity of the senses, but the latter is the necessary basis of the former. I am aware that the joy of discovery does not seem to animate the majority of our advanced pupils. But how can it exist when there is no basis for discovery and when the senses and constructive activities, have not been systematically exercised for a period of eight or ten years? The effort to arouse them to living activity after these years of arrested development is either an impossible task, or is more than most teachers have patience to do. The very same lack of desire to use any part of the body will result from non-exercise of it, and the victim of non-use is ever conscious of his weakness.

4. THE DISCOVERY OF THE UNITY OF ALL NATURE.

When the relating activity has operated for a number of years, the consciousness of the unity of all things begins to manifest itself, but is a product of mature life rather than of school life.

5. PRACTICAL ADVANTAGES OF NATURE STUDY.

Herbert Spencer has shown the value of a knowledge of nature in all the activities of life:—those which directly minister to self preservation; those which indirectly minister to self preservation; those which concern the rearing and disciplining of offspring; those which concern political and social relations; and finally, those which have to do with the leisure period of life.

While Spencer's view is certainly extreme, the force of his argument carries conviction to all.

6. CONQUEST OF THE WORLD.

The activity of mind on environment is a process of destroying it and thereby building itself up. This means that the unrelated becomes related, the strange, familiar. As our physical organism acts upon food, destroys it as such, and rearranges its elements to form a part of itself, so the mental organism acts upon phenomena. A particular fact coresponds to food. The mind seizes it, destroys its particularity and makes it a part of itself. This power of the mind is essential to *successful* existence.

Nature forms most of our environment in early life, as it formed the whole environment of primeval man. Our conquest of it is as necessary to progress as it was to him. The savage, whose conquest of his environment is limited to things of sense, and who has not really conquered it, views it as a mysterious power which rules him in some mysterious way. Such is the view of all superstitious people, and their superstition remains, because they are not conquerors of nature.

> "Lo, the poor Indian, with untutored mind
> Sees God in clouds and hears him in the wind."

How different the view of him who has conquered nature:

> "I do not own an inch of land,
> But all I see is mine
> The orchards and the mowing fields,
> The lawns, and gardens fine.
> The winds my tax-collectors are,
> They bring me tithes divine,
> Wild scents and subtle essences —
> A tribute rare and free;
> And, more magnificent than all,
> My window keeps for me
> A glimpse of blue immensity,
> A little strip of sea."—LUCY LARCOM.

What a fickle being is God to the "untutored mind" which fails to conquer environment, to destroy strangeness, and to see behind phenomena, *law*.

There is still a more disastrous result than this. The onward march of civilization demands rapid and accurate adaptation to environment. Lacking this power to control circumstances, man feels that nature is too powerful for him, and casts about for a remedy. By chance, he partakes of some narcotic, e. g. tobacco, alcohol, hasheesh, etc., and immediately the world seems less formidable, because the senses are less acute in reacting to stimulation. He feels that he can conquer this new world. Humanity is prone to deception; the unreal seems real

and the victim of the paralyzing drug believes it to be an efficient stimulant. How much of our intemperance is due to our helplessness in the face of natural phenomena? The gradual extinction of the Indians, the Maoris, the Sandwich Islanders, and others, is due to their inability to adapt themselves to changing environment. Even coping with our fellow-men is an advanced phase of nature study, and the best preparations for any contingency is the development of the power of adaptation to environment *now*. What are our inventors continually trying to do but to conquer the opposing forces of nature; the inertia of matter; the opacity of solids; the inertness of the conducting ether? And when one inventor succeeds in conquering time and space, do we not all share in the sense of power over nature? The thrill of satisfaction experienced in talking across a continent cannot but make us more courageous, and confident of our power to conquer.

The absurdity of attempting the conquest of nature by thus modifying our conception of it, is at once apparent, and the method which looks to mental development as the basis of conquest will be accepted by all true educationists. Yet there are visionaries who propose just such absurdities, comparable with that of benumbing the senses with alcohol, hasheesh, opium, or tobacco. These men would make the work so easy as to reduce it to play. They would not have the child realize that there is an end which it should consciously strive to attain, but hope that through play this end may be obtained. If the end be attained through play, i. e. activity not consciously directed to an end, there will not be the essential development which can come only by a consciousness of (1) a difficulty to be met; (2) the means to meet it; (3) the will to use these means. The day must come in the natural order of events when the child, grown to man's estate, must face difficulties, and it will be a costly experience for him and perhaps for others, if he has, hitherto, failed to develop those activities which will enable him to adapt himself to them. *Not by decreasing resistance but by increasing mental power must conquest be made.*

What is the Process in Nature Study?

The mental process is the same whatever may be the subject of study. It begins with an undefined, homogeneous whole, which the mind, if interested, immediately begins to analyze into particular parts, aided, of course, by previous experience which has left in the mind notions of these or of similar parts. Comparing these fixed notions with the new particulars, the mind establishes new relations, by which the fixed notion is still further elaborated and the new particular is brought into a familiar relation. It becomes a part of mind. The process of comparison is carried on between the parts of the whole, or more properly between the mental images of these parts, until all are properly related so far as this can be accomplished by the mind in its existing state of development. The farther this relating process is carried, the more clearly will the things related be defined, and the original undefined, homogeneous whole becomes a defined, heterogeneous, yet related whole. We may describe this mental process by saying that within the undefined whole mind moves in two directions, (1) towards the particular; (2) towards the universal. The teacher is apt either to stop with the particular; that is, stop with analysis without securing a corresponding synthesis, or is apt to force

upon her pupils universals which have not resulted from active mental process in the pupil's mind.

In nature study the order of mental process is, therefore, as follows:

(1.) Undefined notions of individual wholes.

(2.) Learning their names, uses, and important characteristics. Animate nature is first of interest, while, later, inanimate nature becomes interesting by the same process.

(3.) Recognition of likenesses and differences.

(4.) Grouping objects according to these likenesses and differences.

(5.) Summarization of facts learned into a connected life history. Unimportant details are here omitted.

(6.) Study of embryonic development.

(7.) Relation of object to whole kingdom. This is classification on a scientific basis.

Each step, as here stated, is an advance in the discovery of relations, ending in an *ideal* state—a knowledge of all relations. A fully rounded course in nature study is not complete without classification, but this is necessarily preceded by years of observing and comparing in preparation for this classification.

1. The child should upon entering school continue that course which he has been following in his previous experience. He should extend his acquaintance with nature, but under more ideal conditions than have hitherto obtained. Distracting influences will be removed, and the material for stimulation will be selected and adapted to a systematic course of development. The study of individual wholes will be followed immediately by analysis, and this in turn must be followed by synthesis. As stated under the general principles of psychology, analysis and synthesis must go hand in hand, and the extent of the analysis will be determined by the power of synthesis. Since the principal mode of synthesis in this stage is modelling, we should not demand minute analysis of objects, nor should we attempt to analyse very complex objects.

2. This study of individuals as wholes will be followed by the study of parts, the uses of the whole and of the parts and the prominent characteristics which will attract the attention of all young pupils. As soon as a clear notion of each part is obtained, the name should be given and the pupil should discover the use of each part by observing the object in its natural surroundings. Naturally a child is first interested in moving things, because his attention is *compelled* to *change from point to point by the external object moving over the field of vision; just as later active attention is secured by moving the eye from point to point of the object.* The child delights in activity, but the teacher must see that the child's own activity is developed and not merely his observation of others' activity. The former means development; the latter arrested development. *The child must express itself by the mode best fitted to its stage of mental power.*

3. Some claim that differences are first noticed by children; others that resemblances are. The fact seems to be that both are phases of one mental process. Two things would not be recognized as two unless they differed, at least, in position, in time, or in space; hence, in recognizing anything we have two judgments, implicit or explicit, i. e., this is not the same object as that; this object is like that. Since the notions of space and time are necessary judgments, we

have the recognition of resemblance as the actual mental process. The child is constantly looking for resemblances, as is shown by his calling all four-legged animals "dogs;" all moving mechanisms "toot-toots;" all coins "dollars." When adults see a strange face, they immediately see a likeness to some familiar face, which those familiar with both, fail to see at all. Hence, mental process seems to proceed from noting resemblances to noting differences. In the study of nature, therefore, we will begin with noting resemblances, and later differences. How is the squirrel like the rabbit? How does it differ? Carry the comparison from whole to part.

4. This recognition of likenesses leads to a grouping of objects which are more like each other than like all others. This grouping is rudimentary and tentative. With increase of analysis and comparison, classification will become more intensive as to species, and more extensive as to characteristics. At first, objects are classed into two classes, with one distinguishing characteristic. For example, plants are either Phanerogams or Cryptogams, the one distinguishing charateristic being the presence of a flower. When we continue the classification to the species, we have reduced the number of plants to one, which has many characteristics distinguishing it from others. Hence, classification is seldom, if ever, final. In nature study, therefore, we begin with large classes based on one distinguishing characteristic, e. g.: Plants divided according to habitat; plants growing in swamps, in water, etc. After a fuller analysis, we group them in Orders, then in Genera, and finally species. At first we classify from external, concrete features; later we base our classification on more ideal features, such as relationship of parts, etc.

5. Whenever a phase of any object has been completely studied, the knowledge gained should be arranged in an orderly way, either as a drawing, diagram, or written composition. This will constitute a life history of the subject of study to date. Each life history should be arranged in the same way so as to expedite comparison. In any such summary unimportant details, which were necessarily noted in the first analysis, will be omitted, whether the summary be in one or other of the above forms. Such a summary is a preparation for the process of generalization. In fact, advance in mode of expression from modelling to the written symbol is a process of omitting details. The mode of expression becomes more comprehensive, more being left to be supplied by mental imagery. At this stage, therefore, nature study is particularly associated with composition.

6. Embryonic development, in its relation to Science, is a part of nature study, which is more properly part of High School work, but the development of the frog, toad, fish, or slug may be observed by young pupils comparatively well, and makes a subject of intense interest. Second Book pupils can study the whole life history of the frog or of the toad, from egg to adult, as easily as they can observe any other natural process. The study of the life history of the butterfly is very easy, as is also that of the mosquito. Often only a part of the development may be observed, but this observation may be supplemented by pictures and verbal descriptions. However, the true bearing of such study does not become clear until an advanced stage of mental progress is reached.

7. The highest stage of nature study is classification on a scientific basis. This means that the discovery of relations among particulars has been carried to

a finality, so that each individual is distinguished from all others. When an object has been classified, then, and not till then, can it be defined. The fullness and finality of the definition depend upon the completeness and correctness of the classification. Such a classification can be made only after years of study. This does not mean that a pupil cannot be taught to use a key and thus find the name of an individual, but such a mechanical operation, though based on the analysis of the object, does not mean what is meant here by classification. We mean by it the actual comparison of the individuals, and the grouping of them into branches, families etc., according to their resemblances and differences, *without the aid of a key.* The key should be constructed by each student for himself, at least in part.

Course in Nature Study.

The clearest exemplification of the preceding principles can be shown most clearly by giving a course of nature study adapted to the different grades in public schools. The course here given has been prepared by the author for a certain system of schools in a Canadian city, and has been in operation for a sufficiently long time (nearly three years) to prove its practicability. It is assumed throughout that the course will be directly related to reading, drawing, and composition, as modes of expression and to geography and physiology. Teachers are also expected to limit the analysis of any object of study according to the power of synthesis of her pupils. Accordingly when we say in grade II. "Review work of preceding grade," we mean that the analysis will be extended in the higher grade. This will be exemplified later in the outline of a lesson on a particular object, the butterfly, adapted to each of the three stages of mental development, primary, secondary and tertiary.

FIRST CLASS, Parts I and II.

Position and appearance of sun, moon and larger stars, observed throughout the year.

Color of sky at different times under varying conditions.

General color of landscape at different seasons.

WINTER.

Ice and snow, Jack Frost, wind,

Winter birds, crow, sparrow, chickadee.

Trees in winter. Comparison of evergreens and deciduous trees.

Study the domestic animals during the winter.

At Christmas study holly and mistletoe.

SPRING AND SUMMER.

Study sap and making maple sugar.

Melting of snow and ice.

Return of the birds—keep a bird calendar.

Food of birds and their actions—singing, nesting.

Common flowers, e. g., trillium, hepatica, spring beauty, etc.—Names, color, place of growth, time of flowering.

Plant seeds, and observe germination and growth.

Observe squirrels, rabbits.

FALL TERM.

A few common plants, seeds and fruits.

Dissemination of such seeds as thistle, burr, dandelion, milkweed, maple.

SECOND READER.

More details about sun, moon, and stars. Color continued. Eclipse of sun or moon if one occurs. Need of sunlight for plants and animals. Movements of plants towards sun.

WINTER.

Study forms of snowflakes.

Different forms of water — ice, water, vapor, steam.

Change from one form to another.

How much of a piece of ice floats below the surface of water? Compare large and small pieces.

Observe twigs, of apple, maple, horse chestnut, spruce. Does spruce shed its leaves? How?

Impress the fact that trees are alive all winter but sleeping. What do birds do in winter? What do bears, squirrels, coons and frogs do?

SPRING AND SUMMER.

Add details to course in Parts I. and II.

Continue bird and plant calendars. Begin a butterfly and moth calendar.

Keep tadpoles in glass jars for two or three months and observe development to adult frog. Write story of its life.

Fish — external features, scales, fins, eyes, mouth, gills. How they swim and breathe.

Young mud turtles — observe them bury themselves in the fall.

Collect larvæ from milkweed, parsley, carrots tomatoes, etc. Keep until they change to chrysalis.

FALL.

Observe emergence of butterflies from chrysalids. Write story of the butterfly. Later observe cocoons and chrysalids which live through winter. Collect cocoons and keep in cool place through winter.

Observe date of departure of common birds. Why do they leave? Use of birds, and why we should protect them.

Look for buds on the trees before the leaves fall.

Observe falling of leaves, change in color, mode of falling. Observe evergreens. What becomes of the fallen leaves if not burned?

Common fall plants: evening primrose, butter-and-eggs, and asters golden-rod, gentians.

Fruits and seeds — dissemination of seeds by various agents, wind, water, birds, etc.

Fruits of apple, horse chestnut and maple, etc., should be examined throughout the year.

Observe plants mentioned in second reader.

THIRD READER.

Motions of sun, moon, earth, and planets, as they appear. Eclipses more fully. Observe different constellations of stars — position of sun at different seasons — effect – position of moon in various months. Observe wind each day — prevailing direction — when strongest — effect on trees. Soil of different kinds, water.

WINTER.

As before passing to consideration of glacier, iceberg, avalanche, Arctic region, its plants and animals. Effects of freezing water on soil, rock, etc.

Observe shapes of trees, nests in them.

Examine structure of buds, twigs.

Winter condition of former animals, also flies, mosquitoes, crayfish, snails, clams, spiders, coccoons and chrysalids.

Study seeds and fruits collected previous fall.

SPRING AND SUMMER.

Collect plants — preserve a few properly named.

Group plants according to place of growth – in water, in swamps, in moist soil, in sand.

Begin to compare plants and find those which resemble each other most bulbs, root stocks, corms, etc.

Observe leaves, bark, wood, and general appearance of forest trees. Use and relation to soil. Compare a tree growing in a forest with one of the same kind growing in the open, away from other trees.

Extent of forests in Canada now and in former years. How to preserve forests — pulpwood.

Birds and animals continued more in detail, passing from local to foreign species by means of pictures and descriptions.

Different kinds of fish — whitefish, herring, perch.

Butterflies and moths. Collect larvæ and note transformation. Injurious species. How to destroy them by spraying.

Life history of a few common insects, e. g., fly, mosquito, butterfly, dragon-fly, codling moth.

FALL.

Collect cones of evergreens – keep till seeds discharge. Observe those which remain on tree all winter. When do they fall?

Plants, especially of sunflower type, (composites). Detailed study of two or three.

Crayfish, spiders, snail, slug, clam, bee — Instinct.

Comparison of the two great types of plants, bean-type and wheat-type. Compare leaves, stems, flowers and seeds.

Improvement of species by grafting, cultivating, selecting seed.

FOURTH CLASS.

Previous course more fully studied, inquiring into *causes*.

WINTER.

Discover causes of cold weather — glacial action.

Summarize knowledge in compositions on "Our Winter Birds;" "The Sleep of Plants;" "Hibernation of Animals;" "How Plants shed their Leaves."

Simple physical and chemical experiments.

SPRING AND SUMMER.

Collection and classification of plants.

Prepare first a rudimentary key before making use of the botanical keys.

Special study of injurious plants throughout the year, and how to destroy them.

Diseases of plants — cause and cure — rust, smut, black-knot, apple scab, blight.

Study of fungi, mosses, lichens, ferns, externally. Poisonous plants, parasites.

Relation of plants to insects.

Compositions — "Cross Fertilization;" "Plant Enemies;" "Movement of Plants;" "Relation of Plants to Soil;" "How Insects Benefit Plants."

ANIMALS.

Classify animals into branches, thus:

Back-boned animals — squirrel type — Vertebrata.

Soft-bodied, boneless — snail type — Mollusca.

Legs, many-jointed — crayfish type — Arthropoda.

Classify Vertebrata in classes.

Cat type — *Mammalia*.

Bird type — *Aves*.

Lizard type — *Reptilia*.

Frog type — *Amphibia*.

Fish type — *Pisces*.

Study smaller forms of animal life, e. g., plant lice and related pests, buffalo carpet beetle, caddice-flies, clothes moth.

Make an extended study of one class of animals, birds, fish, butterflies, moths, spiders.

Let pupils develop individuality.

Summarize as under plants.

Relations of animals to man.

History of certain forms, when introduced, how spread, loss to country annually, directly and indirectly.

Our duty towards animals.

Method of Nature Study.

"A method is derived from a principle."—HARRIS.

After so much has been said about the principle of constructive activity and its action upon environment, there is little to be said on the question of method, except to show the practical application of the principle to each stage of child life. It is evident that our method must vary in these three stages. In each stage we have to consider: (1) the matter of study and how to obtain it; (2) the teacher's work; (3) the pupil's work.

In the first stage the matter of nature study is that with which the pupil can and does come in contact. The immediate environment of the child is the field of study. The extent of the analysis of the matter studied will be determined as heretofore stated by the child's power of synthesis. How shall this matter be obtained? In this primary stage we cannot depend to any great extent upon the pupil's ability to collect, unless under the direct supervision of the teacher. Consequently, teacher and pupils must make excursions together. But frequent excursions are impracticable, if not impossible, and as we cannot take children to nature, we must bring nature to the children. The remarks which follow concerning school gardens, etc., are applicable to all three stages of child-life.

A part of the school yard must be set apart for the reception of plants of different kinds. The limit of the kinds of plants will be determined by the extent of the garden space, and by the nature of the soil, and the possibility of varying the conditions. If one part can be kept shady, another sunny, another damp; if one part is loamy soil, another sandy, another rocky, we can successfully cultivate all varieties of plants, which, ordinarily, would not be found within a radius of many miles. In stocking this garden with root stocks, bulbs and small trees; in planting seeds, and in caring for all, the most important facts about plants will be learned. While a school garden will furnish material for the study of plants and will bring within reach the insects and birds which constantly visit them, it is necessary to have some more limited space in which living animals and plants may be brought into the class-room. There should be a cage, in which rabbits, squirrels, birds, etc., can be kept for a few days, observed, and then set free again.

A "terrarium" for a class-room is an essential part of a museum equipment, and may be stocked from time to time with the proper food plants of the insects which are to be studied. A few young cabbage plants on which the eggs of the cabbage butterfly have been laid; a young potato plant with the eggs of the Colorado beetle, "potato bug;" a carrot, with the eggs of the Eastern swallow tail; all may be used to stock the terrarium and furnish matter for nature study, for weeks, at the proper season. Small animals, e. g., toad, mud-turtle, may be kept in the terrarium and their habits observed, especially their burrowing when cold weather comes on. A small terrarium may be arranged to open to the outer

air and bees can be kept and observed in safety. One moth, kept in a cage on window sill will attract others of its kind of the opposite sex.

Then there must be an aquarium, small enough to be carried about, yet large enough to accommodate small sized fish, cray fish, mud-turtles, etc. A little care in observing and collecting water-plants will soon enable the teacher and pupils to keep a balance between plant and animal life without any further care than to keep the vessel clean, in a favorable light, and to replenish the water as it evaporates. Care must be taken to put just enough food in the aquarium so that none will remain. If too much is put in, the surplus must be carefully removed.

All these are for living things. But there is a place for dead things and pictures of living things, especially if the pictures are in colors. There should be stuffed specimens of representative birds and mammals and preserved specimens of insects and plants for reference and for the purpose of showing how this work should be done. But avoid trying to have a complete set of specimens, and, above all things, do not think that the study of dead specimens, especially dead birds, is nature study. It is better to get your specimens of birds and mammals from a regular taxidermist, rather than to accept them from pupils, who should rather be discouraged from collecting birds and birds' eggs, because of the importance of preserving our birds from complete destruction. Encourage your pupils to expend their collecting energy on insects and plants.

A few life histories of butterflies, moths, and beetles, should be prepared for reference and for review work. Several typical specimens of plants, especially of those more difficult to obtain, should be pressed, dried, mounted, and properly named, in order to show how this work should be done. Specimens from remote districts very properly find a place in the museum, as they will arouse interest in their native country and extend the knowledge of familiar nature.

Finally, although these should not be studied very extensively until the third stage of school-life is reached, specimens of all the common minerals and rocks of the country should be in every museum. If, corresponding to each mineral, pictures of the mines, of mining machinery and of the mining country can be procured, geography may be made a profitable study. Sections of wood, in its natural state and also polished and stained should be obtained. Corresponding to these, pictures of the whole tree in its natural environment should be secured.

The Work of the Teacher and Pupils.

The teacher will first of all select the material for study. Having done this and provided suitable quarters for it, she must direct the analysis and the expression of the pupils in each stage in an orderly way. She must not allow the material to be so great in quantity as to confuse the pupil or to cause dissipation of energy and yet must sustain interest by allowing the pupil's love of activity and discovery to find free play. The chief work of the teacher, at first, is wise questioning suited to the pupil's capacity. We shall illustrate the work of teacher and pupils, in all three stages, in a lesson or series of lessons on the butterfly.

FIRST STAGE, (5 to 8 years of age.)

MATERIAL: Larva, chrysalis, and butterfly—alive.

HOME: Pupils will state where they have seen each. After observing in the class-room, they may observe in their gardens at home.

MOVEMENTS: Observe the larva crawl and eat. Tell how it does these. What does it do when disturbed? Observe it moult and tell what change in appearance results. Observe it pass into the chrysalis state. Does the chrysalis move? How is it fixed? Observe the butterfly emerge from the chrysalis. What does it look like? How does the butterfly move about? Can it walk?

FOOD: What does the larva eat? Does the chrysalis eat? Supply wild flowers and observe the butterfly get nectar. Feed the butterfly with honey and sugar. Tell how it "drinks." How long is its tongue?

COLOR: What is the color of each form?

STRUCTURE: What does the larva look like? Has it a head? How many legs has it? Are they all alike? How many are alike? How, and for what purpose does it use them. What does the chrysalis look like? Has it a head? What does the butterfly look like? How many divisions in its body? How many wings has it? How many legs has it? Observe its head, eyes, antennæ and tell what they are like.

There is very little that the *pupil* can do here beyond making oral descriptions of each observation. Cut out a butterfly from paper, and color it to match. The pupil must learn each of the above facts through his own sense-activity. Mould the chrysalis in clay.

SECOND STAGE, (8 to 12 years of age.)

MATERIAL: Eggs, larva, chrysalis, butterfly. Illustrations of others, or others present.

The child is now capable of depending partly on memory and can also imagine new forms, if aided by the teacher's description.

HOME: Where are the eggs laid? Does the mother watch over them? Upon what plants does the larva feed? What plants will it not eat? Observe at different times of day.

Where is the chrysalis usually found? Gather information about this from different sources.

What flowers does the butterfly prefer? Where does it go at night? In winter? Obtain information from other sources.

MOVEMENTS: Review. Describe its mode of walking, moulting, and eating, definitely. What changes are observed in its activity before and after moulting?

Observe it breathe. Compare with our own breathing.

FOOD: Review. What does it eat most? When does it do most damage? On what does the chrysalis live? Compare the chrysalis with hibernating animals.

COLOR: Review. How does its color harmonize with its surroundings? Compare color of different specimens. How do they vary.

STRUCTURE: Count the number of rings, (segments), in the larva behind the head. On which one are the legs situated? On which segments are the fleshy pro-legs situated? Compare larvæ of different species, actually present or pictured, and decide if they agree in these particulars. Draw the larva.

Compare the chrysalis with the larva, and tell how they resemble each other. Make a drawing of the chrysalis. Compare different chrysalids.

How many parts in the butterfly? How many wings and legs? Where are they attached? Make a drawing of the whole and of the parts. Compare with larva and with chrysalis.

Head and Sense Organs: Examine the eyes with a lens and describe.

Examine the antennæ. Compare with other butterflies and moths. Draw.

Examine the tongue and compare with the mouth parts of the larva.

Can it hear? Experiment to discover.

Can it smell? Experiment to discover.

Eggs: Observe a butterfly deposit its eggs. Where are they deposited? Why? How many are deposited in a place? Keep in a box until they hatch. How long before they hatch? Observe development of the larva and compare different stages with each other, and with other larvæ. Make drawings of each stage to keep for reference.

THIRD STAGE, (12 to 16 Years of Age.)

The aim of the third stage should be to discover relations. Whereas we have been more concerned about the where, how and the what, we now become concerned with the why. Finally, we classify the specimen as minutely as possible.

Material: As before and in addition verbal descriptions of different forms of animal life and an analytical key of each branch, partly, at least, the pupil's own work.

Home: In addition to what has been learned before the student should now determine what effect the larva has on its food plant. Does it destroy it entirely or in part? How does the butterfly benefit the flowers? Why has the butterfly so long a tongue? What relation is there between the length of its tongue and the flowers it visits? What relation exists between the time of appearance of certain butterflies and of certain flowers?

Movements: Why does it moult its skin? Why does it become restless before moulting? Of what benefit is this restlessness to the larva? Has it any movements which are protective? Read about the migration of butterflies, and what they do in winter. Compare with other insects, and with birds.

Food: Why are not certain butterflies found in Canada?

What determines their range?

Which is most easily killed by poisoning, the larvæ or the butterfly? Why?

If you find larvæ on different plants, find from your botany if there is any relationship between these plants. They will probably belong to the same family.

Color: Observe if the different forms are protected by their color?

Compare the color of the larvæ in different conditions.

Compare the color of the chrysalis with the surface on which it rests.

Structure: Compare all the butterflies studied with one another, and with other insects, spiders, etc.

Tell what is characteristic of all butterflies which distinguishes them from moths, beetles, etc. Group the different species studied according to their resemblances. How are they adapted to their mode of living?

Life History: Write a complete account of its life.

Thus the teacher's work is in selecting the material and in directing the pupil's analysis, while the pupil's work is to discover facts about this material, and to give expression to each fact in some way, finally summarizing all these facts in a composition which is virtually the story of the life of the animal studied. In doing this work the mental power is increased in all directions, and the power of expression is incidentally cultivated in an interesting way.

The teacher can do a great deal to correlate nature study with other subjects of school study, e. g., geography and physiology, and should base all training in expression—reading, drawing, and composition, upon it. This phase of the work has been already fully discussed.

It is impossible in view of the relation between the constructive activities of the child and its development to escape the conclusion that manual training and domestic science should occupy an important place in elementary education, especially in the secondary and following stages. Such statements as "social life which does not have its root and background in nature is blind and unregulated;" "nature, apart from the place which it plays in giving instruments by which social life maintains itself, is empty and dead;" "the study of nature is the study of the materials and of the processes by which society maintains itself;" "education is a process of remaking experience, giving it a more socialized value through the medium of increased individual efficiency;" "the aim of the school is to socialize the child;" go to prove that only by repeating typical acts which have operated in the development of the race can the child "remake experience" and thereby interpret his environment.

Now, as before stated, development of the race resulted from the reaction of man upon environment in adapting it to his needs and aims. To adapt himself to the present complex environment it is necessary that he should repeat typical experiences of the race such as carpentering, metal work, cooking, etc. This does not mean that he must master every phase of social experience any more than he needs to own every industrial mechanism in order to feed and clothe himself. But he must know enough about them to be able to interpret them and adapt himself to changing conditions. In the field of literature and art the same typical activities must have been experienced in order that he may appreciate the beauty of expression and form. Hence what is ordinarily designated manual training and domestic science should be considered as the basis of all the school studies. Instead of placing these on the curriculum as separate subjects they should be viewed as modes of expression of the constructive activity of the child, just as reading, writing, drawing, and composition are modes of expression, not separate subjects of study.

Progressive development would lead from the constructive activities to the underlying principles governing the growth of material, the processes of development, the application of force necessary to act upon them; in a word to the sciences, while in later life all would culminate in the highest expression of social experience, literature and art. A complete course in nature study must be correlated with manual training and domestic science.

Study of a Plant in Different Stages of School Life.

PLANT — *Butter-and-Eggs, or Toad Flax.*

Specimens of the whole plant should be obtained by the pupils. They should dig up a few and transplant them in the school garden, or, in absence of an appropriate place, in a box, which may be kept in the school-room. The earlier in the season these plants are obtained the more likely they are to flourish. Try to imitate in the school-room or yard the natural conditions of soil, light, and moisture.

Pupils should observe while collecting, the kind of soil, the location, amount of moisture generally present, all surroundings, and the date of collection. Were there few or many plants together? Did they pull up easily or not? Were there bees or other insects about the flowers? Were there any larvæ feeding upon the plants? Do cattle or other animals eat the plant? How do bees or other insects enter and leave the flowers? Were there any insects about the plants which cannot get at the nectar in the flowers?

In the class-room, root, stem, and leaves may be observed in detail. Everything should be discovered by the pupils themselves, if possible, without waste of time and effort, but there are always certain related facts which may be conveyed to the pupils through pictures or by words, especially in higher classes. The one thing to avoid is the attempt to force the pupils to learn mere forms without actual assimilation. The method of arousing mental activity varies in the different stages as previously stated, and the same holds in the study of plants as in any other study.

FIRST STAGE.

What part of the plant grows above ground? What is the nature of the underground part? Where was this particular specimen found? Tell whether it grew in shade or in sun, in dry, moist or in wet soil, or in water. How many plants grew where the specimens were found? How close together did they grow? Were any of the plants eaten off by animals? What insects were noticed about the flowers? What were they doing?

PART OF PLANT ABOVE GROUND.

How high does it grow? How wide? Are there branches? What kind of leaves are there? Do all the plants bear flowers? What color are the flowers? What odor? How many on each plant? How are they arranged? Are all the flowers open at the same time? What do they look like? Cut out paper flowers and leaves to look like the real ones. Color them.

PART OF PLANT UNDERGROUND.

What kind of structure do the branches grow from? (Give name root-stock.) How many branches grow from one root-stock? How long is a root-stock? Find the fibrous parts growing downward from the root-stock. How many are there? How long? Cut up the root-stock into several pieces and plant all the pieces.

FRUIT.

What is the shape of the fruit? Is it good to eat? Do animals eat it? How many seeds are there in it? Mould clay to the shape of the fruit?

SECOND STAGE.

Review conditions of growth as in first stage. What other plants are growing near it? Compare conditions of plants found in different localities. Do the plants vary with conditions? Compare plants which grow in shade and in sun. Compare plants which grow in moist soil with those in dry soil. What kind of soil seems most favorable to the plant? Why are the plants found in patches? If animals will not eat them, discover why. Observe how bees enter and leave the flowers. What insects cannot enter? Why? What do the bees get from the flowers? What do they carry from one flower to another?

PART OF PLANT ABOVE GROUND.

Review work of first stage. Where does it grow higher, in sun or in shade? In sand or in clay? In moist or in dry soil? What are the highest plants observed? The widest? Look at the plant from above. Describe the appearance of the leaves. How are they attached to the stem? Why are they not placed one above the other? Do the leaves change position in sunlight and at night. Make drawings of whole plant to show various points observed. Describe a leaf fully, and draw. Compare with leaves of other plants. Why are the leaves narrow? Compare the number of leaves with the number on the sunflower or other large leaved plant. Make a diagram showing the order in which the flowers open. What advantage is it to the plant to have flowers open successively? Make a drawing of a flower.

FLOWER.

Observe the different floral organs, calyx, corolla, stamens, pistil. How many parts in each? Show by diagram where each part is situated. How is the corolla adapted to invite the bee to visit it? What attracts the bee? Observe one light on the flower and tell just what happens as the bee lights, enters, and leaves. What part of the bee becomes covered with pollen? What becomes of this pollen? Where is the nectar found?

FRUIT.

Review — Is it dry or fleshy? How long does it take to mature? Does it split open when ripe? How? Why? How many cavities in the fruit? How many seeds? Where are the seeds attached in the fruit? How are the seeds discharged from the pod? Examine a seed and make a drawing. How is it made so as to be carried away? What agent will carry it? Preserve some seeds and plant next spring. Compare with other seeds in shape, size, color, etc.

PART OF PLANT UNDERGROUND.

Review — Account for the plant growing in patches. How does the root-stock grow in length each year? What becomes of the old part? What happens to the plant in winter? Preserve root-stocks and plant them in spring. (Give name perennial, for plant which lives from year to year, after pupils have discovered

this fact.) Compare root-stock with potato tuber, bulb of onion, corm of Indian turnip. Is the root-stock a stem or a root? Why? Compare roots with branches, in size, shape, structure, as far as possible. Compare roots with those of other plants.

THIRD STAGE.

Under the head of each, review work of preceding stages.

Why do the plants grown in different conditions vary? In what kind of soil would a plant of this nature spread most rapidly? How should plants that grow in patches be destroyed? What other plants grow in patches? Compare with this one after inferring in what respects they should agree. What is the relation of the structure of the flower to that of the bee?

PART OF PLANT ABOVE GROUND.

Determine the exact leaf arrangement of the leaves on the stem. Why arranged in this way? Is the stem woody or soft? Are the leaves net veined or parallel-veined? Write a full description of stem, leaf, and mode of flowering, using technical terms. What other flowers resemble this one in mode of flowering? (Inflorescence.) Is the plant an exogen or endogen?

FLOWER.

Write a full description according to some prescribed form, stating the number of parts in each whorl, and the relation of each whorl to each other. Do this first in simple language, and gradually introduce technical terms, such as gamopetalous, etc. Determine the relation between the position of stamens and stigma, which favors cross fertilization by bees. What other flowers have closed corollas? Why? Why is the corolla spurred? What other flowers have spurred corollas? Compare the lengths of the spurs. By what other means do plants favor visits by bees? What other insects cross-fertilize flowers? Obtain further information from books on Nature, by Darwin, Gibson, Grant, etc.

Classify the plant.

FRUIT.

Write a full description of the fruit. Compare with other dry dehiscent fruits. In what ways does the fruit favor the preservation of the plant?

PART OF PLANT UNDERGROUND.

Compare the structure of the root-stock with that of the stem above ground. What is the difference between root-stock and root? Determine the age of the root-stock by counting the rings of wood. Examine the root-stock in the fall and see what preparation has been made for next year's growth. Compare with annuals and biennials.

Matter of Nature Study.

INTRODUCTION TO PLANTS.

OUTLINE OF NATURE-STUDY WORK WITH PLANT LIFE.

Children can be introduced to the study of plants as easily as to any other subject. Just as they learn to know their playmates, so they may learn to know their friends of the woods and fields. When they are interested in a plant because of any feature of it, and ask "what it is?" the teacher should hasten to give them a formal introduction.

"Why, that is a Wake Robin, who lives in the woods over there," or "that is my Lady's Slipper, which was lost many years ago in the forest.

A touch of reality is added by this personification, which is really more strictly in accord with the truth than to consider a plant as so much dead matter. Fancy introducing a child of fourteen years, or less, to a living incarnation of beauty in the terms of a dead language *Cypripedium pubescens.*

The flower should be first treated and studied as a living thing, and afterwards used as material for drawing lessons and for color study. In which is a child more interested, a strip of yellow paper, one by two inches, or the yellow of the Lady's Slipper? And what if it is not pure color? We never think of beginning any other study with the faultlessly perfect in every detail. At any rate, the colors of flowers are never cheap.

We may learn something from Nokomis in Longfellow's "Hiawatha." She was grandmother and teacher to him.

"Many things Nokomis taught him
Of the stars that shine in heaven;
Showed him Ishkoodah, the comet,
Ishkoodah, with fiery tresses;
Showed the death-dance of the spirits,
Warriors with their plumes and war-clubs,
Flaring far away to northward
In the frosty nights of winter;
Showed the broad white road in heaven,
Pathway of the ghosts, the shadows,
Running straight across the heavens,
Crowded with the ghosts, the shadows."

"Saw the rainbow in the heaven,
In the eastern sky, the rainbow,
Whispered, 'What is that, Nokomis?'
And the good Nokomis answered:
'Tis the heaven of flowers you see there;
All the wild-flowers of the forest,
All the lilies of the prairie,
When on earth they fade and perish,
Blossom in that heaven above us.'"

"Of all beasts he learned the language,
Learned their names, and all their secrets,
How the beavers built their lodges,
Where the squirrels hid their acorns,
How the reindeer ran so swiftly,
Why the rabbit was so timid,
Talked with them, when e'er he met them.
Called them, Hiawatha's brothers."

Here was an ideal teacher of nature. There was no dissecting but an interest in what they did.

By some such simple method, the child should, in the course of an ordinary school life, become acquainted with the names of all our common trees and plants. As soon as he is able, he should note likenesses and differences, beginning with the grosser and gradually extending to the finer details, but the teacher must keep within the limits of interest, direct his efforts, yet see that knowledge is acquired through his own self-activity. Classification into orders, genera, and species, should be left for advanced public school work or for introduction to high school work.

While becoming acquainted with the names of trees and plants, quite young pupils can begin systematic work which requires only keen eyes and an interested mind to accomplish. They should note where the plants grow; the kind of soil; the color, etc., and prepare lists of plants according to habitat:

Plants growing in water, sagittaria, eel grass; plants growing in sandy soil, clotbur, evening primrose; plants growing in woods, lily, anemone.

If such work as this is begun in a second form and continued throughout the school course, the child would have a store of information about plants which would be of the greatest value, whatever his future might be.

Another line of work, similar in nature, is grouping plants according to time of flowering, at first by seasons, then by months, and later by definite limiting dates, showing earliest and latest appearance in bloom.

As a guide to teachers, and as an indication of the work that might be done by the pupil in the course of seven or eight years, a list of common plants is given in the appendix, grouped according to habitat and color of flowers, with the time of flowering indicated by figures, denoting the month, and letters denoting the seasons.

The study of plants so far, in the schools of Canada, has been almost entirely limited to minute descriptions of individual plants with a view to their exact classification. While this work is quite in place for the advanced student, it is quite unsuited to the younger classes. Furthermore, the basis of classification has been the flower to the exclusion of the leaf. As the latter is a much more permanent part of the plant than the flower, a classification based upon it has many advantages. In any case children should be trained to recognize plants by their leaves and general appearance, so that they can gather them at any time during the season and examine them.

After a class has once learned to know a plant, it should be collected at regular intervals, say every month, and its development and changes noted. The importance of such examination may be seen in the case of the dandelion, which immediately after flowering season should be examined daily, until the fruit is

fully formed. Then the life story of it may be written just as we would write the life story of a frog, or other animal.

This periodic examination will lead up to the formation and development of fruit, and the dispersal of seeds. The seeds should be preserved in labelled packages, planted in the following spring, and their germination and early growth noted, thus completing the observation of the life-cycle.

While doing such work as the above, the pupil will discover the distinction between annuals, biennials, and perennials. Usually this distinction is brought before the student after a few months' study, but, evidently, no one can appreciate the distinction until a type of each class has been studied for two or more years.

Thus, the study of plants, "in the large," will be followed by the study of their more particular structure: the buds, leaves, flowers, fruit, and seeds. Each of these may be taken in turn, and studied minutely.

Bring into your school-room, in March, branches of different trees, e. g., maple, apple, horse-chestnut. Keep their cut ends immersed in water, or in moist soil (cutting the ends occasionally,) and observe the development of the bud. What becomes of the brown scales? How is the bud protected? Where are the buds situated? Which buds develop first? Are there any which will not develop in the room? Observe the development of buds on the tree later. What is a bud? How does it grow? Find the buds which become flowers. Which appear first, the leaves or the flowers?

In the maple, the flowers are noticeable first, in the apple both develop together, while in the horse-chestnut the tree is in full foliage before the flowers appear. Try to discover other trees like each of these types in respect to the appearance of the flowers, compared with the leaves.

Following the plan suggested in a preceding paragraph, observe these trees at least once a month throughout the season. The development of the fruit should be followed closely and a record of observations kept. Does each blossom produce a fruit? If not, about how many of the blossoms do produce fruit? Of fruits which set how many mature? What causes some of the fruit not to develop? Open those fruits which fall early to discover the cause of their non-development.

Study the structure of the fruits of the trees mentioned. (Third book pupils can do this.) In the maple fruit, the peculiar wing and the manner of falling are noticeable; in the horse-chestnut, the burr or shell, and the richly colored brown nuts; in the apple, the fleshy fruit and seed cavities. How many seed cavities are there? How many seeds in each cavity? Look for other fruits like each of these types. Thus the ash and the elm have winged fruits; the chestnut and beech-nut have burrs; the pear and quince are fleshy. Why are fruits green while immature, and brown when ripe? Do these colors protect them in any way?

In higher classes, the study of buds may be continued, in order to find when, where and how, new buds are formed each year. Examine the branches closely each month. You will find that the buds are formed early in the season before the leaves fall. Where are they formed? How and when are they coated with resin? What other protection have they? Open one to see. Try to discover all that is contained in a bud. Study the mark (scar) left by the leaf after it has fallen from the tree; also the ring-like marks of the scales of a bud. The

distance between these ring-like marks represents a year's growth, hence the age of a shoot can be determined by observing these. The little spots scattered over the surface of the stem are breathing pores (lenticels.) Where are they most numerous?

The terminal buds continue the growth of the stem next year. Some of the axillary buds develop and produce lateral branches. But many of the axillary buds never develop unless some accident happens to the terminal buds. Break off the terminal buds of healthy branches on a tree and note the result.

A few years ago the tussock moth larvæ destroyed the entire foliage of shade trees in Toronto and elsewhere. Later in the season the trees were not only covered with leaves but flowers as well. Sometimes in spring, trees leaf out early and have their leaves totally destroyed by late frosts, but the reserve buds are sufficient to renew the foliage and prevent the death of the trees.

During the winter, trees and shrubs should be observed as to outline, habit of branching, nature of bark, etc. Leafless trees are especially valuable as objects for drawing lessons, and birds' nests can then be observed, which escaped detection in the summer.

The nature of the wood itself should be studied, so that unscrupulous dealers can not pass off black ash for oak, or stained pine for mahogany.

In autumn, study the falling of the leaves. Some trees shed their leaves suddenly, e. g., horse-chestnut, walnut; some shed them gradually, e. g., maple, poplar; some retain a few brown and withered leaves throughout the winter, e. g., oak, beech. When do these latter leaves fall? Why? Group the trees according to these different ways of shedding their leaves.

Study the evergreens. Do they shed their leaves? One is apt to answer "No;" but is immediately reminded of the bed of pine needles which carpet the ground under the old pines. Cut off a branch of a pine or spruce which has a leafless portion. Observe the different years' growth. Examine the leaves on each year's growth. Which year's growth is entirely leafless? What portions have lost part of the leaves? What portions have lost no leaves? Compare different evergreens, as some shed ther leaves in a different way from others. Notice the Scotch pines and yellow pines in October. Certain groups of the leaves are noticeably yellow and falling. Which year's growth is this? In what way are evergreens better adapted to withstand winter weather than maples? Which kind of tree will flourish better far to the north?

The cause of the falling of leaves is not, as is generally supposed, due to frost, though a frost may hurry the process of falling. The leaves would die if there were no frosts, as you may observe many do early in the season. Examine the point of connection between the leaf and the tree at different times during the year, and try to discover the cause of falling.

ROOTS.

There are many interesting facts about roots, which may be made the subject of nature study. They must be distinguished from underground stems, which bear buds. In origin they grow from the descending axis of the plant. Observe sprouting seeds and distinguish the ascending axis (stem) from the descending axis (root.) Examine the small rootlets for the root-hairs, which

absorb water. Where are these root-hairs most numerous? Why are roots so irregular, unlike stems? How would the soil affect the regularity of a root?

Each root has a root-cap at its tip, which is constantly renewed as it is worn off by the soil, through which it forces its way. This root-cap is a very important part of the root.

Examine the roots of clover and other members of that family of plants (bean, pea, etc.) You will find small enlargements called "nodules." These nodules play a very important part in the nourishment of these plants, as they are tenanted by minute forms of plant life (bacteria), which have the power of assimilating nitrogen directly from the air, which plants and animals cannot do. Thus the plants of the clover family are rich in nitrogen, and are valuable fertilizers of the soil, as farmers have long known. A crop of clover ploughed under is the very best preparation for a crop of wheat. In Germany, these bacteria have been cultivated and prepared for sale, just as phosphates are sold as fertilizers.

One of the best nature study exercises is to have each pupil plant a dozen or more seeds of various kinds, (wheat, bean, pea, corn, melon,) and report each week or oftener upon their growth. The teacher should keep a few seeds of the same kind growing for class demonstration, to correct errors and suggest new work.

TREES THAT SHED THEIR BARK.

We are all familiar with the phenomenon of trees shedding their leaves. We know, too, that in spring they shed the scales which enclosed the buds all winter. Later they shed most of the parts of the flower, the calyx, the corolla, and the stamens. Then, usually, at the close of the season, the fruit falls. There are exceptions to nearly all these statements, but generally speaking they are true.

Most of our trees shed their bark also. This is most evident on the sycamores and birches, but it is none the less true of other trees. In winter the branches of the sycamore glisten along the river valleys, and the lateness of the leaves in spring marks these trees distinctly against the surrounding greenness.. This process of shedding the bark is quite evident in the white pine, from which the bark scales in rather regular four-sided patches. The shag-bark hickory sheds its bark in strips, which gives the name to the tree, while the rough surfaces of the maple, oak, walnut, and other trees shows that the same process is going on there though less regularly. It is, in fact, a necessity of their mode of growth.

The growth of our common trees takes place in the area just under the bark, or between the bark and the wood. This area is called the cambium. It grows both inwards and outwards, forming wood on the inside and bark on the outside. As the tree increases in circumference, the bark of previous years' growth is shoved outward, but being too small to cover the increased circumference it splits more or less irregularly, and eventually scales off very quickly and completely in the sycamore, and more slowly in the maple and other trees.

Some trees, e. g., palm, and some plants, e. g., corn, lily, do not grow as above described, and in these there is no bark, although the outer layers of cells are somewhat different from the inner ones. These trees and plants have points of growth throughout the stem, and the wood is formed at these points in bundles.

In the more advanced classes the pupils should observe the relation between

plants and the soil. Some plants flourish best in sandy soil, and are likely to crowd others out of such soil, though these others might be able to grow there, if not in competition with these natives, as they may be called. Other plants grow in water, and cannot possibly live on dry land. Others grow in swamps, others in shady woods, some in sunny places, and some prefer mineral soil. Thus, of trees, evergreens prefer sandy or gravelly soil, while the hardwood trees, oak, maple, beech, need a heavier soil, clay loam. Willow and sycamore grow beside flowing streams, and tamarack in cold, wet soils. The study of these groups of trees may be carried on for several years.

Modern botany places great stress upon the study of the adaptation of plants to environment, which is known as ecology. Plants are found to grow in societies, according to the nature of the soil, moisture and climate. Thus, we have peat bog societies, swamp societies, forest societies, desert societies, fence-corner, and roadside societies.

Four great societies are now recognized: (1) Water plants, i. e., those which grow where water is abundant, (Hydrophytes); (2) Drought plants, i. e., those which grow in extremely dry soil, and in a dry atmosphere, (Xerophytes); (3) Plants that grow where there is a medium water supply, (Mesophytes.); (4) Plants that grow in soil which contains a large amount of mineral matter, (Halophytes).

Appendix.

The numbers stand for the months of flowering; S — summer; A. S. — all summer; L. S. — late summer.

PLANTS OF ROADSIDE, BANKS, ETC.

FLOWERS WHITE.

Shepherd's Purse, 4-11.
Virginia Creeper, 7.
Hedge Bindweed, A. S.
Bouncing Bet, S.
Musk-Mallow, 6-9
White Sweet Clover, 7-9,
Wild Carrot, 6-9.
Mayweed, (yellow disk), 7-9
Boneset, 8-9.
Yarrow, 7-9.
Asters, 6-0.
Rib Grass, (Eng. Plantain,) 3.
Round-leaved Mallow, 6-10.

FLOWERS YELLOW.

Charlock, 6-8.
Mustard, 6-9.
Wood Sorrel, A. S.
Butter and Eggs, 6-10.
Yellow Sweet Clover, 7-9.
Tansy, 6-10.
Elecampane, S.
Mayweed, (white ray,) 7-9.
Mullein, 7-9.
Wild Sunflower, L. S.

FLOWERS PINK, RED, ETC.

Sweet Brier, 6-9.
Apocynum, 6-7.
Bouncing Bet, S.
Catnip, 7-9.
Musk Mallow, 6-9.
Yarrow, 7-9.
Teasel, 5-8.

FLOWERS BLUE, PURPLE.

Common Speedwell, 6-8.
Wild Toad Flax, 7-9.
Clue Vetch, 7-9.
Chicory, (also white, or pink,) 7-0.
Viper's Bugloss, 6-8.
Asters, S.
Beggars Lice, 6-8.
Blue Vervain, 5-6.
Self-Heal, 6-9.

PLANTS OF DEEP WOODS

FLOWERS WHITE.

Solomon's Seal, 5-6,
False Solomon's Seal, 5.
False Lily of the Valley, 5-6.
Wake Robin, 4-5.
Painted Trillium, (crimson veins,) 4-5.
Canada Violet, S.
Blood Root, 4-5
Toothwort, 4-5.
Leek, 6
Mitrewort, 5.
False Mitrewort, 5.
Bunch Berry, 6.
Shin-Leaf, 5-7.
Indian Pipe, 6-7.
Dutchman's Breeches, 4-5.
Squirrel Corn, 4-5.
Wood Sorrell, 6-7.

FLOWERS YELLOW.

Wild Ginger, 4-5.
Blue Cohosh, 4-5.
Yellow Lady's Slipper, 7.
Yellow Wood Sorrell, 5-9.

FLOWERS PINK, OR RED.

Wild Orange-red Lily, 6-8.
Herb Robert, 6-8.
Shin-Leaf, 6-7.
Pink Lady's Slipper 6.
Twin Flower, 6.

PHLOX FLOWERS, BLUE, OR PURPLE,

Twisted Stalk, 5-6.
Ill-scented Wake Robin, 4-5.

PLANTS GREEN.

Jack in the Pulpit.

PLANTS OF SANDY SOIL

FLOWERS WHITE.

Asters, 5.

FLOWERS YELLOW.

Rock Rose, 7-8.
Yellow Evening Primrose, 6-9.
Hairy Puccoon, 6-7.
Columbine, 6-7.
Sweet Golden Rod, 8.
St. John's Wort, 6-9
Stone-Crop, 6-8.

FLOWERS PINK, RED.

American Sea Rocket, 7-8.
Clotbur, L. S.
Bush Clover, L. S.
Bird's-eye Primrose, 5-6.

FLOWERS BLUE OR PURPLE.

Wild Lupine, 6-7.
Asters, 7.
Purple Gerardia, 7.

PLANTS OF OPEN WOODS, AND GROVES.

FLOWERS WHITE.

Hepatica, 3-4.
May Apple, 5
Wood Anemone, 4-5.
Star Flower, 5.
Rue Anemone, 4-5.
White Avens, 5-8.
Thimble Weed, A. S.
Five-leaved Ginseng, 6-8.
Twin Leaf, 4-5.
Wild Sarsaparilla, 6.

FLOWERS YELLOW.

Downy Yellow Violet, 5
Dog's-Tooth Violet, 4-5.

FLOWERS PINK, RED, ETC.

Spring Beauty, 4-5.
Lousewort, (also yellow,) 5-7.
Wild Geranium, 5-7.
Purple-flowering Raspberry, 6-8.

PLANTS OF DRY SOIL.

FLOWERS WHITE.

Thorn Apple, 6-9.
Everlasting, 4-5.
Dodder, (parasitic) 1-8.
Fleabane, (yellow disk) 6-7.
Wild Carrot, 8-9.
Ox-Eye Daisy, (yellow disk) 6-7.

FLOWERS YELLOW.

Buttercup, 6-9.
Five-Finger, 5-8.
Shrubby Cinquefoil, A. S.
Silvery Cinquefoil, A. S.
Evening Primrose, 6-9.
Barberry, 5-6.
St. John's Wort, S.
Mullein, 7-9.
Black-Eyed Susan, S.
Dandelion, A S.
Golden Rod, 8-9.
Prickly Lettuce, 6-9.

FLOWERS PINK, RED, ETC.

Great Willow Herb, 7-9.
Milkweed, 6-8.
Canada Thistle, S.
Wild Bergamot, 7-8.

FLOWERS BLUE OR PURPLE.

Blue Violet, 4-5.
Viper's Bugloss, 6-8.
Ground Ivy, 4-5.
Indian Tobacco, 6-8.
Self-Heal, 6-9.
Hound's Tongue, 5-7.
Corn Cockle, 7-9.
Thistle, 7-10.
Wild Bergamot, 7-8.

FLOWERS GREENISH WHITE.

Poison Ivy, 6-7.

PLANTS OF MOIST SOIL.

FLOWERS WHITE.

Choke Cherry, 4-5.
Dogwood, 6-7.
Cut-leaved Toothwort, 4-6.
Plantain, (about dwellings) S.
Poison Hemlock, 6-8.
White Violet, 5.
Elderberry, 6-7.
Chickweed, A. S.
Virgin's Bower, 7-8.

FLOWERS YELLOW.

Dog's Tooth Violet, 4-5.
Meadow Parsnip, 5-6.
Jewel Weed, S.
Money Wort, S.
Loosestrife, 6-7.

FLOWERS PINK OR RED.

Small Willow Herb, S.
Turtle Head, L. S.
Cardinal Flower, 8.
Mint, 8-9.
Oswego Tea, S.

FLOWERS BLUE OR PURPLE.

Blue Flag, 5-6.
Blue-Eyed Grass, 6-8.
Common Harebell, 6-9.
Forget-me-not, 6-8.
Ground Ivy, 5-6.
Nightshade, 7-9.
Blue Vervain, 6-8.
Fringed Gentian, 8-9.
Closed Gentian, 9-10.

PLANTS OF SWAMPS.

FLOWERS WHITE.

Gold Thread, 5-6.
Round-leaved Sundew, 6-7.
Poison Sumach, 6.
Water Hemlock, 6-8.
White Swamp Honeysuckle, 6-7.
Creeping Snowberry, 5
Grass of Parnassus. 9
Water Parsnip, 7-9.

FLOWERS YELLOW

Marsh Marigold, 4-5.
Bur Marigold, S.

FLOWERS PINK, RED, ETC.

American Cranberry, 6.
Showy Lady's Slipper, 5.
Swamp Milkweed, S.

FLOWERS BLUE OR PURPLE.

Pitcher Plant, (varies) 6.
Skunk Cabbage, (variegated) comes up through ice sometimes, 3-4.
Purple Avens, 5-7.
Asters, 7-9.
Marsh Five-Finger, S.

PLANTS IN WATER.

FLOWERS WHITE.

Wild Calla, 6.
White Water Lily, A. S.
White Water Crowfoot, A. S.
Water Hemlock, A. S.
Water Parsnip, A. S.
Arrow Head, A. S.
Water Plantain, L. S.
Eel Grass, 8.
Water Cress, 5-6,

FLOWERS YELLOW.

Yellow Pond Lily, 5-8.
Yellow Nelumbo, 7-8.
Yellow Water Crowfoot, A. S.
Potomageton, 7-8.

FLOWERS BLUE.

American Brooklime, 5-9.

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